INHERITANCE OF BODY WEIGHT, EGG WEIGHT AND AGE AT FIRST EGG IN WHITE LEGHORN BIRDS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "INHERITANCE OF BODY WEIGHT, EGG WEIGHT AND AGE AT FIRST EGG IN WHITE LEGHORN BIRDS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Mannuthy,
11-10-1982.

VALSALA C. JOSEPH.

CERTIFICATE

Certified that this thesis, entitled "INHERITANCE OF BODY WEIGHT, EGG WEIGHT AND AGE AT FIRST EGG IN WHITE LEGHORN BIRDS" is a record of research work done independently by Smt. Valsala C.Joseph under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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Dedicated

to

My Loving Parents

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Introduction

INTRODUCTION

Chicken, Gallus domesticus, is not at all considered as a mere game bird, now-a-days. It has attained a major significance in the field of animal production, as a supplier of food products of high quality. Poultry production depends mainly on the efficiency of selection and breeding techniques, aiming at improvements in the available stock by increasing the frequency of favourable genes.

Poultry breeders are interested in making genetic improvements in the economic characters. Since White Leghorn is an egg type bird, improvement is directed towards egg production characters. Age when egg production starts has long been thought to be a deciding factor in the number of eggs produced. Egg weight is gaining more and more importance now-a-days as evidenced by the grading of eggs based on size as well as sale on weight basis. In the past, lack of attention for this character has resulted in decrease in egg size. Body weight eventhough not as such important for the egg production in White Leghorns, its relationship with production traits is to be looked into.

The most important parameter while studying the inheritance of quantitative characters is the heritability estimate. This estimate gives an indication of the amount of progress that can be made through selection. While attempting for genetic improvement in one or more traits, information on the relationship of these characters is essential.

Although several experiments have been made on the inheritance of economic characters among different breeds of poultry in different places, only very little information on the genetic control of these characters in poultry in Kerala is available. The present study was therefore undertaken with a view to estimate the heritability of body weights, age at first egg and egg weight and also the genetic, phenotypic and environmental correlations among these traits.

Review of Literature

REVIEW OF LITERATURE

Work done on the estimates of heritability and correlation among egg production traits in poultry is reviewed briefly under the following headings:

1. Body weight
2. Age at first egg
3. Egg weight.

1. Body weight

Body weight has been found to be a character of polygenic inheritance. Several studies were made on the inheritance of body weight in different breeds and strains of poultry and the results has been varying.

Hazel and Lamoreux (1947) analysed the records on White Leghorns to estimate the heritability, maternal effects and nicking in relation to body weight and sexual maturity. They reported the heritability of body weight at 22 weeks of age as 31.6 per cent with standard error 4 per cent and that 5 per cent of the variation in body weight was due to maternal effects and no evidence was found that sex-linked genes influenced body weight. Negative phenotypic and genetic correlations of -0.33 and -0.44 respectively were found between these two traits.

According to Blyth (1952) body weight was consistently positively correlated with egg weight. Godfrey *et al.* (1953) reported that the influence of egg weight, age at sexual maturity and adult body weight account for about 36 per cent of the variation observed in body weight at 12 weeks of age in a strain of New Hampshire.

A study was conducted by Krueger (1953) to estimate the heritability and correlation of different production traits in Leghorns. Heritability estimates for 20 weeks body weight based on full sib correlation was 0.43 and based on regression of progeny on dam was 0.32 and concluded that the trait is influenced by both additive and non-additive gene effects.

Yamada (1958) conducted a study to estimate the heritability and genetic correlations of economic characters in chickens. Heritabilities based on combined sire and dam components were 0.46 for body weight at 300 days and it was concluded that individual selection would be most effective for improving body weight. Hogsett and Nordskog (1958) reported that the heritability estimates for body weight were 0.45 in light breeds on the basis of sire.

Rodero and DeMiguel (1961) analysed the data on White Leghorn pullets to estimate the heritability of body weight at 4 months of age. The dam-daughter regression method gave the heritability as 0.3458 and maternal influence was estimated as 0.6 per cent of the total variation. It was suggested that the low figure of maternal influence was due to a considerable influence of sex-linked genes and individual selection was found to be most efficient for increasing body weight.

Hurnik (1963) estimated the heritability of body weight as 0.61 in White Leghorn birds. Baczkowska et al. (1963) reported the heritability calculated from sire + dam components as 0.280 to 0.359 in Rhode Island Red for body weight.

Kawahara (1965) reported the genetic correlation between body weight and egg weight as 0.543 in domestic fowls. The genotypic and phenotypic correlations between body weight and egg weight in White Leghorns were -0.30 and 0.10 (Hurnik, 1965). Shibata (1965) calculated the heritability from sire and dam components as 0.248 ± 0.083 and 0.579 ± 0.056 for adult body weight in White Leghorn and the genetic correlation between adult body weight and egg weight was 0.652 ± 0.106.

Kawahara and Inoue (1966) obtained the sire and dam component heritabilities as 0.895 and 0.346 for body weight in the domestic fowl. Hill et al. (1966) reported the heritability from sire + dam components as 0.66 ± 0.25 for body weight.

The phenotypic correlation of body weight with age at first egg in White Leghorn birds was found to be 0.474 ± 0.072 by Kumar and Kapri (1967). Rao and Bose (1967) suggested that at twenty weeks of age, the weights of winter and summer hatched chicks were significantly higher than those of monsoon and spring hatched chicks in White Leghorns.

Galvano (1968) reported a positive correlation between body weight and egg weight in laying hens. Kaszvica *et al.* (1968) got the mean value of body weight at 20 weeks as 1.5 kg in White Leghorn fowls.

Kolstad (1971) reported the heritability of body weight as 0.53 in poultry. Mohapatra and Ahuja (1971) found the heritability of mature body weight to be 0.15 and -0.12 in White Leghorn birds based on paternal half-sib correlation and full-sib correlation methods respectively. Tardalbjan (1971) estimated correlations of -0.17 and 0.28 for hen's weight at five months with age at first egg and egg weight respectively. He found correlation between body weight at ten months of age and egg weight to be 0.45 in White Leghorns. Significant genetic correlation of 0.26 to 0.72 between body weight and egg weight in five White Leghorn lines in two years respectively was reported by Kovalenko and Kosenko (1971). Casey and Nordskog (1971) suggested that the gene action for body weight in Leghorns is multiplicative, sex-linkage or maternal effects for the trait was not important.

K rishna and Chaudhary (1972a) stated that dam component estimates of heritability in White Leghorns were generally greater than sire component estimates, maternal effects on body weight were found until 16 weeks of age. The hatch, sire and dam components of variances were found to be important in the variation of body weight in White Leghorns by Krishna and Chaudhary (1972b).

Manson (1973) stated that egg weight and body weight in White Leghorn fowls are genetically positively correlated. The average body weight at five months of age and its heritability were estimated to be 996 g and 0.57 respectively by Taylor et al. (1973).

Arthur and Beck (1974) estimated the heritability of body weight in chickens as 0.61 using analysis of covariance method, the genetic correlation between body weight and egg weight being 0.35. According to Vanchev et al. (1974) body weight of White Leghorn females averaged 1800 g and the mid-parent heritability was 0.40 for body weight at 154 days. Trehan and Dev (1974) estimated the average value and sire component heritability of 40 weeks body weight of chickens as 1708.5 g and 0.84 respectively. Egg weight was correlated with body weight (0.26).

Heritability computed by Chaudhari et al. (1976) from variance component analysis indicated that body weight is moderate to highly heritable in White Leghorn chickens and it was positively correlated with egg weight and age at first egg. Nikolov et al. (1976) obtained the heritability of body weight as 0.16 and 0.15 in Shaver 6-E and 5-A lines of White Leghorns. The correlation of body weight with egg weight was 0.18 for both the strains. Chand et al. (1976) reported that no significant increase in body weights in White Leghorns is found in caged birds beyond the age of 140 days, the heritabilities were 0.27 and 0.56 for body weight in two flocks.

Highly significant strain differences were observed by Sarma et al. (1977) in the average body weight at 20 weeks of age among the 6 White Leghorn strains studied. Natarajan and Rathnasabapathy (1977) reported that body weight of White Leghorns is influenced significantly by hatch date variation whether it was larger or shorter duration of hatching. Johari et al. (1977) reported that White Leghorn pullets attaining high body weight at 20 weeks of age matured earlier and the heritability was estimated to be 0.18 ± 0.007 for 20 weeks body weight. Reddy (1977) obtained the heritability of body weight as 0.26 to 0.53 in White Leghorns. Natarajan (1977) estimated the average body weight at 20 and 40 weeks of age as 1000 g and 1579 g and the heritabilities were 0.20 and 0.18 respectively in White Leghorns. The genetic correlation of 20 weeks weight with 40 weeks weight was 0.84. It was inferred by Rao *et al.* (1977) that the egg quality traits of White Leghorns have fairly high additive genetic variability.

Reddy *et al.* (1978) showed that body weight at 20 weeks of age was moderately heritable in four strains of White Leghorns. Nikolov and Belorechkov (1978) obtained the average body weights at 20 weeks of age as 1435 g and 1566 g in two strains of White Leghorns. The correlation of body weight with egg weight was 0.18 and 0.12, and the heritabilities were 0.15 and 0.11 for 20 weeks weight. Natarajan and Rathnasabapathy (1978) estimated the heritabilities based on half-sib correlation as 0.20 and 0.18 for body weights at 20 and 40 weeks respectively in White Leghorn pullets.

Ipe and Singh (1979) obtained the heritability of pullet weight at 16 weeks as 0.302 ± 0.064 and its correlation with age at sexual maturity as -0.197 ± 0.185 in White Leghorns. The heritability of 20 weeks weight in Meyer strain of White Leghorns was found to be moderate by Patel and Rathnasabapathy (1979).

Ipe and Varkey (1980) reported the correlation of pullet weight with egg weight as 0.290 ± 0.189 in a White Leghorn population. Body weights at 20 and 40 weeks of age were found to have heritabilities less than 0.2 by Natarajan and Rathnasabapathy (1980). Maan (1980) studied 240 White Leghorn pullets and obtained the average value and heritability of 20 weeks weight as 1270 g and 0.50. Ahlawat et al. (1980) obtained the genetic and phenotypic correlations of -0.27 and -0.13 between 20 weeks weight and age at sexual maturity in Babcock strain of White Leghorn. Heritability of age at first egg of desi fowls was found to be 0.79 ± 0.20 by Kumar and Acharya (1980). Jayanna et al (1980) reported the phenotypic correlation of body weight at housing, egg weight as 0.202 ± 0.023 and that with age at sexual maturity as -0.90 ± 0.023.

From the results of various experiments, it can be seen that body weight is moderate to highly heritable. Influence of sex-linked genes and maternal effects also is found to be existing in the inheritance of this trait. In general, it could be seen that association of body weight with egg weight is positive whereas such generalization could not be made about the relationship with age at first egg in different breeds of poultry.

2. Age at first egg

Age at first egg is generally considered as an important factor in determining life time egg production of the bird. According to Hays (1924) sex-linked as well as autosomal genes are involved in the inheritance of age at first egg.

Hazel and Lamoreux (1947) obtained heritability of age at first egg to be 26.6 per cent with 4 per cent standard error.

Lerner and Cruden (1951) obtained a heritability of 0.2 to 0.3 for age at sexual maturity. Hays (1951) found that age at sexual maturity had a slight positive effect on mature body weight in Rhode Island Red pullets.

Krueger (1953) estimated the heritability of sexual maturity in Leghorn to be 0.20 from twice the full-sib correlation and 0.07 from regression of progeny on dam method. Sexual maturity was found to be influenced partially by sex-linked genes.

The heritability of age at first egg in White Leghorns was estimated to be 0.522 by King and Henderson (1954) in White Leghorns. Onishi (1954a) found the heritability of sexual maturity to be 0.09 and 0.23 in White Leghorns in two years respectively. Onishi (1954b) suggested the influence of sex-linked genes in the inheritance of age at sexual maturity in Single comb White Leghorns.

Yamada (1955) estimated the heritability of sexual maturity in White Leghorns as 0.48 and no maternal effect was found. The estimated genetic correlations were 0.005 for sexual maturity and mature body weight; -0.217 for sexual maturity and body weight at sexual maturity.

Sacki and Katsuraj (1957) obtained genetic correlation of +0.5 between weight of the first egg and the age at first egg in White Leghorns.

Yamada (1958) obtained the heritability of sexual maturity as 0.48 in White Leghorn based on combined sire and dam components.

Zielinski (1959) reported that early sexual maturity is correlated with higher body weight during the growing period in White Leghorns. The correlation between age at first egg and final weight was -0.060.

King (1961) estimated the heritability of age at first egg, maternal effects and dominance effects in the Regional Cornell Control population to be 0.26, 0.08 and 0.04 respectively.

Husain and Singh (1964a) obtained genetic correlation of 0.38 between age and weight at maturity in White Leghorns. Lowe and Heywang (1964) showed that increasing day length decreases days to first egg in White Leghorns pullets.

Husain and Singh (1964b) got the heritability of age at first egg in White Leghorns as 0.17 ± 0.24 from a flock of 16 sire groups and 123 half-sibs. There were highly significant genetic correlations of 0.384 between age at first egg and body weight at maturity and 0.406 as phenotypic correlation and 0.497 between age at first egg and egg weight.

Shibata (1965) calculated the heritability from sire and dam components as 0.306 ± 0.064 and 0.316 ± 0.057 for age at first egg in White Leghorns.

Reutt _et al._ (1966) estimated the heritability of age at sexual maturity as 0.42 based on the performance of full and half sisters in White Leghorns. Saeki _et al._ (1966a) found age at first egg ranging from 173.5 (New Hampshire) to 199.0 (White Leghorn) days. Heritabilities from sire + dam components varied between breeds from 0.38 to 0.64 for age at first egg and there was a maternal effect also on the trait.

Kawahara and Inoue (1966) obtained the sire and dam component heritabilities as 0.407 and 0.483 for age at sexual maturity in domestic fowl. Saeki _et al._ (1966b) reported the heritability from sire + dam components as 0.39 ± 0.16 for age at first egg in White Leghorns.

The heritability of age at first egg in White Leghorn birds was found to be 0.15 ± 0.25 by Kumar and Kapri (1967), the phenotypic correlation of age at first egg with body weight was 0.474 ± 0.072. Malik and Singh (1967) obtained the heritabilities based on sire, dam and sire + dam components as 0.43 ± 0.22, 0.46 ± 0.24 and 0.46 ± 0.20 respectively for age at sexual maturity in White Leghorns.

Kumar and Kapri (1968) stated the correlation coefficient between age at maturity and egg weight in White Leghorn birds as 0.11 ± 0.63 genetic, 0.14 ± 0.09 environmental and 0.11 ± 0.09 phenotypic. The average heritability estimate of sexual maturity in White Leghorns was 0.32 according to Kinney _et al._ (1968). In a study conducted by Nordskog and Briggs (1968) about the body weight egg production paradox, lowering body weight by 0.1 kg from an overall mean of 1.5 kg decreased age at maturity by 4 days on the genetic scale but increased by 14 days on the environmental scale. According to Tandon _et al._ (1968) the average age at first egg was 221.4 days for the dams and 196.0 days for the daughters in White Leghorns, the heritability of age at first egg was 0.284 ± 0.088, the dam-daughter correlation for age at first egg was 0.22.

Zuk (1969) obtained the correlation between age at first egg and autumn egg weight as 0.54 in White Leghorns. Acharya *et al.* (1969) estimated the heritability of age at first egg in White Leghorn flocks as 0.370 ± 0.005, 0.80 ± 0.016 and 0.224 ± 0.040 based on sire, dam and full-sib components respectively.

The results of the experiment by Aggarwal (1970) indicated that selection for early sexual maturity in White Leghorn pullets will result in birds which lay a large number of small sized good quality eggs. The average value and co-variance were 188 days and 9.6 per cent respectively. There was a significant phenotypic correlation of -0.739 between age at first egg and 4 months egg production.

Based on paternal half-sib correlation and full-sib correlation, Mohapatra and Ahuja (1971) estimated the heritabilities of age at sexual maturity in White Leghorns to be 0.75 and 0.34 respectively. Hussaini and Das (1971) showed that average age at first egg in White Leghorn was 196.5 days. The sire component and dam component heritabilities were 0.47 and 0.43 respectively. Significant correlation of -0.17 was found by Tordalbjan (1971) between age at first egg and hen's weight at 5 months in White Leghorns. Analysis of data on White Leghorn pullets by Penteado (1971) showed that age at sexual maturity was not significantly correlated with body weight. Abdel - Gawad and El - Ibiary (1971) obtained the heritability of age at sexual maturity as 0.59 in White Leghorn pullets.

In the analysis of data of 967 single comb White Leghorn pullets hatched over 2 year period, Sandhu and Dev (1972) found that age at first egg averaged 176.2 days and the estimated heritability was 0.40. Hussaini and Rizvi (1972) observed a tendency of early hatches to mature late in White Leghorn pullets, a highly significant sire effect on age at first egg was also found. Singh et al. (1972) reported that average age at sexual maturity of White Leghorns as 176.2 days. Kumar and Mohan (1972) estimated the heritability of age at first egg as 0.26 ± 0.20 in White Leghorn birds.

Nanda et al. (1973) obtained the pooled heritability of 0.200 for age at sexual maturity in White Leghorn pullets and correlations of 0.595 between egg weight and age at sexual maturity. Correlations between age at first egg and average egg weight was found to be 0.14 - 0.56 and 0.10 - 0.26 in two types of egg producing fowls by Tomilova (1973). Taylor et al. (1973) estimated the age at maturity in White Leghorns as 200 days, the heritability as 0.03.

Vanchev et al. (1974) obtained the mid-parent heritability of age at first egg as 0.44 in a White Leghorn line.

Iqbaluddin et al.(1975) estimated the heritability of age at sexual maturity based on sire and dam components to be 0.24 ± 0.04 in White Leghorn. Phenotypic and genetic correlation between age and weight at sexual maturity was positive. Han and Ohh (1975) gave the average values (days) and heritabilities of age at first egg as 179, 0.33; 181, 0.44 and 186, 0.13 respectively in 3 strains of White Leghorns. The average age at first egg and its heritability in White Leghorn hens were estimated to be 170.6 days and 0.50 by Thak et al. (1975), the genetic correlation of age at first egg with initial egg weight was 0.50.

Chaudhari et al. (1976) stated that heritability for age at sexual maturity in White Leghorns was moderate and there was positive correlation among age at first egg, body weight and egg weight. The genetic correlations were found to be 0.40 ± 0.17 for egg weight and age at sexual maturity in Meyer strain of White Leghorn birds (Sivaswamy et al., 1976). The heritabilities of age at first egg in White Leghorn birds were calculated to be 0.163 and 0.618 based on sire and dam-components respectively and there was significant genetic correlation of egg production with age at first egg, -0.69 (Singh et al., 1976).

Sarma et al. (1977) reported highly significant strain differences in the age at sexual maturity in White Leghorn birds. Heritability of age at sexual maturity was calculated to be 0.19 ± 0.08 by Johari *et al.* (1977). Chung (1977) estimated the heritability based on variance components as 0.48 for age at sexual maturity and the genetic correlations were 0.18 between egg weight and age at sexual maturity and -0.07 between body weight and age at sexual maturity in White Leghorns. Reddy (1977) observed the heritability of age at sexual maturity as 0.2 to 0.28 in White Leghorns. Kosba *et al.* (1977) estimated the heritability of age at sexual maturity in White Leghorn as 0.30, 0.23, and 0.36 based on sire + dam components, sire components and dam components respectively. Virmani and Singh (1977) reported the average age at first egg as 178.39 days and its heritability as 0.51 in White Leghorns.

Age at sexual maturity was found to be low heritable in White Leghorns by Reddy *et al.* (1978). The genetic correlation was negative between age at sexual maturity and 20 weeks body weight. Body weight at sexual maturity was found to be correlated with age at first egg (-0.128) in Single Comb White Leghorns by Yeo and Ohh (1978). Sharma *et al.* (1978) stated that hatch effect is significant for age at sexual maturity in White Leghorns and the average age at sexual maturity was 221 days in White Leghorns. Natarajan and Rathnasabapathy (1978) obtained the heritability of age at sexual maturity as 0.02 based on half-sib analysis in White Leghorn pullets.

Age at sexual maturity was found to be low heritable in White Leghorn fowls by Patel and Rathnasabapathy (1979). Average age at first egg was estimated to be 161.2 days and heritability 0.28 ± 0.10 in White Leghorns by Ipe and Singh (1979).

Yi and Ye (1980) got the heritabilities of age at first egg in White Leghorns as 0.36 and 0.04 from half-sib and full-sib data respectively. Maan (1980) obtained the average age at first egg and its heritability as 170 days and 0.50 in White Leghorn pullets. Jain <u>et al</u>. (1980) observed the average age at sexual maturity and the heritability as 198.36 ± 15.81 days and 0.24 ± 0.01 in White Leghorns. Age at sexual maturity was genetically correlated with body weight (0.94 ± 0.01). A genetic correlation of -0.27 and -0.13 were reported by Ahlawat <u>et al</u>. (1980) between 20 weeks body weight and age at sexual maturity in Babcock strain of White Leghorns.

Age at sexual maturity was significantly influenced by hatching date in White Leghorns as reported by Ahlawat and Chaudhary (1981). Gurung and Taylor (1981) obtained the average value and heritability of age at sexual maturity in White Leghorns as 199.34 ± 0.56 days and 0.11 ± 0.13 (paternal half-sib method) respectively.

From the above reports, it is evidenced that age at first egg is moderately heritable in most cases. Significant strain differences and sex-linkage are also observed.

3. Egg weight

Egg weight is an important quantitative character influenced by several undetermined genes. Hays (1940) suggested that the genes affecting egg weight were autosomal, indicating that genes for egg weight are transmitted equally from sires and dams.

Lerner and Cruden (1951) obtained a heritability of 0.6 for egg weight in chicken. They could not find any positive extra genetic maternal influence in the inheritance of egg weight.

A significant sire effect on egg weight in poultry was reported by King and Bruckner (1952) which would indicate that sex-linkage was a factor in the inheritance of egg weight. A positive correlation between egg weight and body weight in fowls was reported by Blyth (1952). The work by Roberts et al. (1952) suggested that egg weight in White Leghorns used in the study was influenced by several genes without dominance and that males and females are of equal importance in determining egg weight.

Midtid (1953) concluded that egg size in White Leghorns was less affected by environment, sex-linkage was less important and dominance insignificant. Osborne (1953) suggested that sex-linked inheritance may be operative in the case of egg weight in Brown Leghorns.

Henderson (1954) obtained the average egg weight in White Leghorn as 57 g and found that egg weight was not dominant or sex-linked. The heritability of early egg weight and March egg weight in the domestic fowl were estimated to be 0.337 and 0.475 by King and Henderson (1954). Osborne (1954b) reported a marked evidence of sex-linkage for the variance component of egg weight in Brown Leghorns.

Large individual differences in Leghorns were observed in egg weight (48.9 - 63.5 g) by Gleichauf and Mehnert (1956).

Saeki and Katsurag (1957) reported a high genetic correlation (+0.5) between the weight of the first egg and the age of the bird when it started to lay in White Leghorns.

Yamada (1958) got the heritability of egg weight at first egg as 0.49 in White Leghorn, on combined sire and dam components. Hicks (1958) obtained the unweighed average heritability of egg weight as 0.51 in White Leghorns. Hogsett and Nordskog (1958) reported the heritability of egg weight as 0.41 in light breeds based on sire component.

Mostageer and Kamar (1961) suggested the influence of maternal effect in the inheritance of egg weight in White Leghorns. King (1961) obtained a heritability of 0.62 for 32 weeks egg weight. Higher estimates of heritability from dam's variance components indicated maternal effects of 0.03 and dominance effects was 0.24. The sire estimate of heritability for egg weight was found to be 0.36 in White Leghorns by Crittenden and Bohren (1961).

Pinan (1962) obtained the heritability estimate in White Leghorns as 0.15 to 0.23 and 0.13 to 0.22 based on sire and dam components for egg weight at 9 months of age. Inheritance of egg weight is reported to be not affected by sex-linked genes in pullets by Henderson (1962). Waring et al. (1962) gave the heritability estimate of egg weight as 0.7 and no evidence of sex-linked effects was found in the flock. Heritability of egg weight in White Leghorns was found to be 10 per cent at 9 months of age by Rico (1962).

Heritability of egg weight was found to be 0.51 in White Leghorn birds by Hurnik (1963). The heritability of egg weight was found to be 0.51 and 0.54 by Gruhn and Wendt (1963) in two flocks of White Leghorns.

Heritability of average egg weight was found to be 0.81 ± 0.37 in White Leghorns by Husain and Singh (1964b) and there were highly significant phenotypic correlation of 0.497 between egg weight and age at first egg.

Kawahara (1965) obtained the heritability of egg weight in domestic fowl as 0.336 and 0.324 from sire and dam components and the genetic correlation between body weight and egg weight was 0.543. Heritability of egg weight in White Leghorns was found to be 0.36 and genetic and phenotypic correlation between body weight and egg weight were -0.30 and 0.10 (Hurnik, 1965). Shibata (1965) calculated the heritability from sire and dam components as 0.197 ± 0.065 and 0.629 ± 0.85 for egg weight in White Leghorns and the genetic correlation between egg weight and adult body weight was 0.652 ± 0.106. Auxilia and Mastrorillo (1965) estimated the average egg weight as 56.31 with covariance of 7.84 in White Leghorn.

The heritability of egg weight in White Leghorns was estimated to be 0.734 ± 0.09 from sire components by Kumar and Kapri (1966). Saeki *et al.* (1966b) reported the heritabilities from sire + dam components as 0.21 ± 0.07 for egg weight in White Leghorns. Kawahara and Inoue (1966) obtained the sire and dam component heritabilities as 0.386 and 0.465 for egg weight in domestic fowl. Hill *et al.* (1966) reported the heritability from sire + dam components as 0.62 ± 0.28 for egg weight in White Leghorns.

Malik and Singh (1967) obtained the heritabilities based on sire, dam and sire + dam components as 0.46 ± 0.23, 0.63 ± 0.25 and 0.54 ± 0.20 respectively for egg weight in White Leghorns. The sire and dam component heritabilities were 6.1 - 16.9 and 25.2 - 55.4% for egg weight in White Leghorns as recorded by Orlov and Zlocevskaja (1967). It was considered by Festing and Nordskog (1967) that egg weight in White Leghorns is controlled by both dependant and pleiotropic genes. Phenotypic and genetic correlations between egg weight and body weight declined significantly over the generations but there was not a significant trend in heritabilities.

According to Kumar and Kapri (1968) genetic, environmental and phenotypic correlations of egg weight with age at maturity in White Leghorns were 0.11 ± 0.63, 0.14 ± 0.09 and 0.11 ± 0.09 respectively. Galvano (1968) found that egg weight in hens is increased significantly as age and body weight increased. The average heritability estimates for 32 weeks egg weight in White Leghorns was 0.46 according to Kinney *et al.* (1968).

Zuk (1969) obtained the heritability of autumn and spring egg weights in White Leghorns as 0.39 and 0.43 respectively and the correlation between age at first egg and autumn egg weight was 0.54 and that between autumn and spring egg weights was 0.22.

Kovalenko (1970) obtained the heritability of egg weight as 0.29 to 0.57 in Leghorns. The heritabilities calculated from dam components were higher than those from sire components. Aggarwal (1970) calculated the average value and covariance as 48 g and 4.8 per cent for egg weight in White Leghorn pullets. Heritability of egg weight in White Leghorn pullets was found to be ranged between 0.32 and 0.39 by Acharya et al. (1969) and had a high genetic correlation with other egg quality traits.

Kolstad (1971) stated that the egg weight in chicken averages 59.5 g with covariance of 5.2 and the heritability was 0.60. Mohapatra and Ahuja (1971) derived the heritability of egg weight in White Leghorn as 0.65 and 0.31 based on paternal half-sib and full-sib correlation methods respectively. Tardalbjan (1971) showed significant correlations of 0.28 and 0.45 in White Leghorns between egg weight and hen's weight at 5 months and 10 months respectively. Investigations carried out by Penteado et al. (1971) showed a correlation of 0.25

between body weight and average weight of the eggs laid during the first 45 days of lay in White Leghorns. In 5 White Leghorn lines analysed by Kovalenko and Kosenko (1971), egg weight averaged 56.7 to 60.1 g. Sire and dam component heritabilities were 0.10 to 0.36 and 0.11 to 0.53. There was significant genetic correlation of 0.26 to 0.72 between body weight and egg weight. Casey and Nardskog (1971) suggested that the gene action for egg weight in Leghorns is multiplicative, sex-linkage as maternal effects for the trait seemed not to be important. Abdel - Gawad and El-Ibiary (1971) reported the heritability of egg weight as 0.5 in White Leghorn pullets.

Reddy et al. (1972) obtained the average egg weight as 46.9 g in White Leghorn pullets and there was a significant correlation of 0.43 between average egg weight and age at sexual maturity. According to Kaatz (1972), heritability of egg weight ranged from 0.34 to 0.47 in poultry.

Manson (1973) stated that body weight and egg weight in White Leghorns are genetically positively correlated. Nanda et al. (1973) obtained a pooled heritability of egg weight as 0.792 in White Leghorns and correlation of 0.595 between egg weight and age at sexual maturity.

Arthur and Bock (1974) estimated the heritability of egg weight in chickens as 0.51, the genetic correlation between body weight and egg weight was 0.35. According to Vanchev *et al.* (1974), egg weight averaged 56.4 g in White Leghorns and the mid-parent heritability was 0.53. Average egg weight and the sire component heritability were found to be 51.66 g and 0.44 respectively by Trehan and Dev (1974).

Smith and Bohren (1975) suggested that egg weight is increased as the age of the pullet is increased. Han and Ohh (1975) reported average values and heritabilities of egg weight as 50.25, 0.66; 51.26, 0.15 and 52.74, 0.15 respectively in 3 strains of White Leghorns. The heritability of egg weight in White Leghorn hens was estimated to be 0.54 to 0.64 by Ignatov *et al.* (1975) and the genetic correlation between egg weight and body weight was 0.31. Thak *et al.* (1975) observed the average egg weight and the heritability as 49.5 g and 0.40 in White Leghorns.

The heritability of egg weight in White Leghorn strains was found to be moderate to high by Chaudhari *et al.* (1976) and it was positively correlated with body weight and age at first egg. Sivaswamy *et al.* (1976) obtained the genetic correlation as 0.40 ± 0.17 for egg weight and age at sexual maturity in Meyer strain of White Leghorn birds. The heritability of egg weight was found to be 0.16 and 0.18 in Shaver 6-E and 5-A lines of White Leghorns and the correlation with body weight was 0.18 in both the strains, by Nikolov *et al.* (1976). Singh *et al.* (1976) calculated the heritabilities of egg weight in White Leghorn birds as 0.402 and 0.244 based sire and dam components respectively. Chand *et al.* (1976) obtained the heritability of egg weight as 0.74 and 0.51 in two flocks of White Leghorns.

Egg weight in White Leghorn chickens was found to be influenced significantly by hatch date variation, by Natarajan and Rathnasabapathy (1977). Krutikova (1977) reported the heritability of egg weight as 0.74 and 0.51 in two flocks of egg producing fowls. The average value and heritability estimate of egg weight in White Leghorns was reported to be 54.8 g and 0.61 respectively by Virmani and Singh (1977).

Gurung and Taylor (1978) estimated the average egg weight as 51.22 ± 3.19 g and the heritability was 0.15 and 0.61 from sire and dam components of variance respectively. The heritability of average egg weight based on half-sib correlation was found to be 0.32 in White Leghorn pullets by Natarajan and Rathnasabapathy (1978).

Natarajan and Rathnasabapathy (1980) obtained the heritability of egg weight as 0.32 in Meyer strain of White Leghorns. Mean (1980) got the heritability of egg weight as 0.50 in White Leghorns.

From the above literature, it is seen that the trait is moderate to high heritable. Influence of sex-linked genes and maternal effects also reported.

Materials and Methods

MATERIALS AND METHODS

The data for the study were collected from the All India Co-ordinated Research Project (AICRP) on Poultry for Eggs, affiliated to the College of Veterinary and Animal Sciences, Mannuthy.

The AICRP functioning at Mannuthy was started on 1-11-1976. The centre now maintains two strains viz. IWN and IWP brought from AICRP on Poultry for Eggs, Hyderabad. The birds are reared under optimum feeding and management and strict disease control measures are taken in the project.

Each strain is reproduced from 40 selected sires mated to 240 selected dams at the rate of six hens per cock. About 1500 pullets of each strain are raised every generation. Pedigree hatched chicks are reared in brooder houses till they are transferred to grower houses at five or six weeks of age. They are housed in individual cages at the age of 16 weeks. The weights of the birds of each strain are taken at 20 weeks and 40 weeks of age. Age at first egg is recorded based on the first egg of the bird. Average egg weights are recorded for each pullet based on at least four consecutive eggs at 38 to 40 weeks of age. Birds are ranked based on Osborne's index considering the number of eggs produced upto 280 days of age. Some consideration is given to egg weight also while selecting the birds from the rank list. Males are selected on the basis of sire and and dam family averages only.

The characters considered for the study were:

1. body weight at 20 weeks of age
2. body weight at 40 weeks of age
3. age at first egg
4. egg weight.

The data for analysis belonged to ten hatches of N and P strains. The details about the distribution of sires, dams and progenies included in the study are shown in Table-1.

The mean, standard error and coefficient of variation were estimated for all the four characters in the two strains seperately as per the methods given by Snedecor and Cochran (1967).

The effects of hatch were studied by Least Square's Analysis for non-orthogonal data using the technique described by Harvey (1966). The model used was:

$Y_{ij} = \mu + h_i + e_{ij}$ where

Y_{ij} - the observation on the j^{th} individual of the i^{th} hatch.

μ - population mean when equal subclass numbers exist.

h_i - effect of the i^{th} hatch

e_{ij} - random error $N(0, \sigma^2_e)$

The restriction $_i h_i = 0$ was imposed and least squares

<u>Table 1</u>

Distribution of sires, dams and progenies included in the study

Strain						
Character	Sires	Dams	Progenies	Sires	Dams	Progenies
20 weeks body weight	85	412	2259	89	383	1514
40 weeks body weight	85	399	1927	87	370	1338
Age at first egg	85	409	2132	89	378	1441
Egg weight	85	394	1782	87	363	1263

constants for hatch effects were estimated. The significance of hatch effects was tested using 'F' values. When effects were significant constants were used to adjust the data.

Estimation of heritability

The model used for the estimation of heritability (Becker, 1975) was

$$Y_{ijk} = \mu + s_i + d_{ij} + e_{ijk} \text{ where}$$

Y_{ijk} = observation on the k^{th} progeny of the j^{th} dam mated to the i^{th} sire

μ = common mean

s_i = effect of the i^{th} sire

d_{ij} = effect of the j^{th} dam mated to the i^{th} sire

e_{ijk} = uncontrolled environmental and genetic deviations attributed to the individual.

All effects are random, normal and independent with expectations equal to zero.

Analysis of variance table

Source of variation	d.f.	SS	MS	EMS
Between sires	S-1	SS_s	MS_s	$\sigma^2_W + k_2\sigma^2_D + k_3\sigma^2_S$
Between dams within sires	D-S	SS_D	MS_D	$\sigma^2_W + k_1\sigma^2_D$
Between progeny within dams	$n_{..}$-D	SS_W	MS_W	σ^2_W

S - number of sires
D - total number of dams
$n_{..}$ - total number of progeny

SS_S, SS_D and SS_W are the sum of squares and MS_S, MS_D and MS_S are the mean sum of squares due to sire, dam and progeny respectively.

k_1 = number of dams per sire

$$= \left\{ n_{..} - \sum_i \frac{\sum_j n_{ij}^2}{n_i} \right\} / \text{d.f. (dams)}$$

k_2 = number of progeny per dam

$$= \left\{ \sum_i \frac{\sum_j n_{ij}^2}{n_{i.}} - \frac{\sum_i \sum_j n_{ij}^2}{n_{..}} \right\} / \text{d.f. (sires)}$$

k_3 = number of progeny per sire

$$= \left\{ n_{..} - \frac{\sum_i n_{i.}^2}{n_{..}} \right\} / \text{d.f. (sires)}$$

where

$n_{..}$ = total number of progenies

n_{ij} = number of progeny per dam

$n_{i.}$ = number of progeny per sire

σ^2_W = random effect mean square, variance among within dam within sire.

$= MS_W$

σ^2_W = dam component of variance

$$= \frac{MS_D - MS_W}{k_1}$$

σ^2_S = sire component of variance

$$= \frac{MS_S - MS_W - \frac{k_2}{k_1}(MS_D - MS_W)}{k_3}$$

The estimates of heritability were then calculated by the formulae:

$$h^2_s = \frac{4\,\sigma^2_s}{\sigma^2_S + \sigma^2_D + \sigma^2_W}$$

$$h^2_d = \frac{4\,\sigma^2_D}{\sigma^2_S + \sigma^2_D + \sigma^2_W}$$

$$h^2_{s+d} = \frac{2(\sigma^2_S + \sigma^2_D)}{\sigma^2_S + \sigma^2_D + \sigma^2_W}$$

The standard errors of heritabilities were estimated from variances of sire and dam variances:

$$\text{Var}\,(\sigma^2_S) = \frac{2}{k^2_3}\left(\frac{MS_S^2}{d.f._{(S)}+2} + \frac{MS_D^2}{d.f._{(d)}+2}\right)$$

$$S.E.\,(\sigma^2_S) = \sqrt{\text{Var}\,(\sigma^2_S)}$$

$$S.E.\,(h^2_s) = \frac{4 \times S.E.\,(\sigma^2_S)}{\sigma^2_S + \sigma^2_D + \sigma^2_W}$$

$$\text{Var}\,(\sigma^2_D) = \frac{2}{k^2_2}\left(\frac{MS_D^2}{d.f.(d)+2} + \frac{MS^2_W}{d.f._{(w)}+2}\right)$$

$$S.E.\,(\sigma^2_D) = \sqrt{\text{Var}\,(\sigma^2_D)}$$

$$S.E.\ (h^2_D) = \frac{4 \times S.E.\ (\sigma^2_D)}{\sigma^2_S+\sigma^2_D+\sigma^2_W}$$

$$Var\ \sigma^2_W = \frac{2\ (MS_W)}{d.f._{(W)}+2}$$

$$Cov\ (\sigma^2_S\sigma^2_D) = \frac{Var\ \sigma^2_W - k_1{}^2\ Var\ \sigma^2_D}{k_1k_3}$$

$$S.E.\ (h^2_{s+d}) = \frac{2\sqrt{Var\ (\sigma^2_S)+Var\ (\sigma^2_D)+2\ Cov\ (\sigma^2_S\sigma^2_D)}}{\sigma^2_S+\sigma^2_D+\sigma^2_W}$$

Correlations

The analysis of variance models and procedures for two characters, X and Y are the same as given previously for the estimation of heritability. The variance components $\sigma^2_{S(X)}$, $\sigma^2_{S(Y)}$, $\sigma^2_{D(X)}$, $\sigma^2_{D(Y)}$, $\sigma^2_{W(X)}$ and $\sigma^2_{W(Y)}$ are obtained as before.

Analysis of covariance table

Source of variation	d.f.	SCP	MCP	EMCP
Between sires	S-1	SCP_S	MCP_S	$Cov_W+k_2Cov_D+k_3Cov_S$
Between dams within sires	D-S	SCP_D	MCP_D	$Cov_W+k_1Cov_D$
Between progeny within dams	$n_{..}-D$	SCP_W	MCP_W	Cov_W

k_1, k_2 and k_3 are estimated as in the analysis of variance.

(a) Genetic correlations

1. Sire components of variance and covariance

$$r_G = \frac{4\, Cov_S}{\sqrt{4\,\sigma^2_{S(X)}\; 4\,\sigma^2_{S(Y)}}}$$

2. Dam component of variance and covariance

$$r_G = \frac{4\, Cov_D}{\sqrt{4\,\sigma^2_{D(X)}\; 4\,\sigma^2_{D(Y)}}}$$

3. Sire + dam components

$$r_G = \frac{Cov_S + Cov_D}{\sqrt{\sigma^2_{S(X)} + \sigma^2_{D(X)}}\;\sqrt{\sigma^2_{S(Y)} + \sigma^2_{D(Y)}}}$$

(b) Environmental correlations

1.

$$r_E = \frac{Cov_W - 2\, Cov_S}{\sqrt{\sigma^2_{W(X)} - 2\,\sigma^2_{S(X)}}\;\sqrt{\sigma^2_{W(Y)} - \sigma^2_{S(Y)}}}$$

2.

$$r_E = \frac{Cov_W - 2\, Cov_o}{\sqrt{\sigma^2_{W(X)} - 2\,\sigma^2_{D(X)}}\;\sqrt{\sigma^2_{W(Y)} - 2\,\sigma^2_{D(Y)}}}$$

3.

$$r_E = \frac{Cov_W - Cov_S - Cov_D}{\sqrt{(\sigma^2_{W(X)} - \sigma^2_{S(X)} - \sigma^2_{D(X)})(\sigma^2_{W(y)} - \sigma^2_{S(Y)} - \sigma^2_{D(Y)})}}$$

(c) Phenotypic correlation

$$r_P = \frac{Cov_W + Cov_S + Cov_D}{\sqrt{\sigma^2_{W(X)} + \sigma^2_{S(X)} + \sigma^2_{D(X)}}\ \sqrt{\sigma^2_{W(Y)} + \sigma^2_{S(Y)} + \sigma^2_{D(Y)}}}$$

Results

RESULTS

The mean, standard error and coefficient of variation obtained for body weights at twenty and forty weeks of age, age at first egg and egg weight in N and P strains are presented in Table 2. The mean values and standard error for 20 weeks body weight (g), 40 weeks body weight (g), age at first egg (days) and egg weight (g) were found to be 1181.5 ± 2.8, 1457.0 ± 4.0, 166.0 ± 0.3 and 51.7 ± 0.1 for N strain and 1245.9 ± 5.4, 1518.6 ± 5.7, 162.1 ± 1.1 and 51.7 ± 0.1 for P strain respectively.

Least squares analyses of variance for hatch effect on all traits showed that the effect was significant for all traits except for egg weight in both the strains (Tables 3a and 3b). The Least squares constants used for the adjustment of data in N and P strains are given in Table 3c. The Least squares constants for heritabilities were 12.71, 27.39, 20.64, -80.40, -77.62, 12.70, 69.33, 10.06, 28.12 and -22.93 for 20 weeks body weight (g); 111.53, 100.86, 143.35, 141.12, -110.43, -88.66, -77.56, -120.67, -52.96 and -46.58 for 40 weeks body weight (g) and 8.88, 4.78, 7.80, 13.04, -2.46, -7.02, -7.41, -5.76, -7.18 and -4.67 for age at first egg (days) for N strain. The constants for hatches in P strain were -44.79, -120.67, -51.51, -73.60, 51.45, 102.17, 51.81, 107.44, 32.82 and -55.12 g for 20 weeks body weight, 195.67, 155.12, 154.65,

Table 2

Mean, Standard error and coefficient of variation of 20 weeks body weight, 40 weeks body weight, age at first egg and egg weight in N strain and P strain

Strain	N Strain			P Strain		
Characters	Mean	S.E.	C.V.	Mean	S.E.	C.V.
20 weeks body weight(g)	1181.5	2.8	11.1	1245.9	5.4	16.8
40 weeks body weight (g)	1457.0	4.0	12.0	1518.6	5.7	13.8
Age at first egg (days)	166.0	0.3	8.5	162.1	1.1	26.3
Egg weight (g)	51.7	0.1	6.9	51.7	0.1	8.1

Table - 3a

Least squares analysis of variance for body weights at 20 weeks and 40 weeks of age in White Leghorns

		Body weight at 20 weeks		Body weight at 40 weeks	
Strain	Source	d.f.	Mean squares	d.f.	Mean squares
N Strain	Hatch	9	409852.43**	9	1993513.22**
	Error	2249	15754.19	1917	21232.45
P Strain	Hatch	9	766202.18**	8	2660115.29**
	Error	1504	39404.32	1329	28130.65

** Significant $P < 0.01$.

Table - 3b

Least squares analysis of variance for age at first egg and egg weight in White Leghorns

Strain	Source	Age at first egg d.f.	Age at first egg Mean squares	Egg weight d.f.	Egg weight Mean squares
N Strain	Hatch	9	10306.84**	9	65.09
	Error	2122	157.06	1772	267045.51
P Strain	Hatch	9	18386.70**	8	43.74
	Error	1451	1708.94	1254	268059.49

** Significant $P \angle 0.01$

Table 3c
Least Squares Constants for 20 weeks body weight, 40 weeks body weight and age at first egg for N and P strains.

Strain	Characters	h_1	h_2	h_3	h_4	h_5	h_6	h_7	h_8	h_9	h_{10}
N strain	20 weeks body weight	12.71	27.39	20.64	-80.40	-77.62	12.70	69.33	10.06	28.12	-22.93
	40 weeks body weight	111.53	100.86	143.35	141.12	-110.43	-88.66	-77.56	-120.67	-52.96	-46.58
	Age at first egg	8.88	4.78	7.80	13.04	-2.46	-7.02	-7.41	-5.76	-7.18	-4.67
P strain	20 weeks body weight	-44.79	-120.67	-51.51	-73.60	51.45	102.17	51.81	107.44	32.82	-55.12
	40 weeks body weight	195.67	155.12	154.65	..	-108 .17	-76.23	-97.87	-44.82	-47.36	-130.99
	Age at first egg	11.46	25.47	13.68	-0.67	-10.67	-9.99	-5.27	-9.94	-7.18	-6.89

-108.17, -76.23, -97.87, -44.82, -47.36 and -130.99 g for 40 weeks body weight, 11.46, 25.47, 13.68, -0.67, -10.67, -9.99, -5.27, -9.94, -7.18 and -6.89 for age at first egg weight respectively. Data were adjusted for significant effects to determine heritability estimates and correlations.

2. Heritability estimates

The analyses of variance in the estimation of heritability of the four traits under study for N and P strains are shown in Table 4, 5, 6 and 7.

The sire, dam and sire + dam components were 0.25 ± 0.00, 0.36 ± 0.01 and 0.31 ± 0.01 for 20 weeks body weight; 0.22 ± 0.00, 0.50 ± 0.03 and 0.36 ±0.00 for 40 weeks body weight; 0.20 ± 0.00 , 0.22 ± 0.03 and 0.21 ± 0.00 for age at first egg and 0.43 ± 0.00 , 0.62 ± 0.03 and 0.52 ± 0.01 for egg weight respectively for N strain.

The estimates for P strain were 0.25 ± 0.02, -0.19 ± 0.12 and 0.03 ± 0.04 for 20 weeks body weight; 0.44 ± 0.00, 0.27 ± 0.04 and 0.35 ± 0.02 for 40 weeks body weight; 0.06 ± 0.00, -0.11 ± 0.04 and -0.00 ± 0.02 for age at first egg and 0.28 ± 0.01, 0.95 ± 0.04 and 0.61 ± 0.02 for egg weight.

3. Correlations

The analyses of covariance in the estimation of genetic, phenotypic and environmental correlations between four traits

Table 4

Analyses of Variance Table in the heritability of 20 weeks body weight in N strain and P strain

Strain	Source	d.f.	SS	MS	heritabilities		
N strain	Between sires	84	4645317	55301.392	$h^2_s = 0.25 \pm 0.00$	$h^2_d = 0.36 \pm 0.01$	$h^2_{s+d} = 0.31 \pm 0.01$
	Between dams within sires	327	6341346	19392.495			
	Between progeny within sires	1847	24444518	13234.759			
P strain	Between sires	88	6949048	78966.454	$h^2_s = 0.25 \pm 0.02$	$h^2_d = -0.19 \pm 0.12$	$h^2_{s+d} = 0.03 \pm 0.04$
	Between dams within sires	294	9417967	32033.901			
	Between progeny within dams	1131	42897088	37928.459			

Table 5

Analyses of Variance Table in the heritability of 40 weeks body weight in N and P strains.

Strain	Source	d.f.	SS	MS	heritabilities
	Between sires	84	5148289	61289.154	
N strain	Between dams within sires	314	8928354	28434.248	$h_s^2=0.22\pm 0.00$; $h_d^2=0.50\pm 0.05$; $h_{s+d}^2=0.36\pm 0.00$
	Between progeny within dams	1528	26625957	17425.364	
	Between sires	86	7530076	87559.023	
P Strain	Between dams within sires	283	7945659	28076.064	$h_s^2=0.44\pm 0.00$; $h_d^2=0.27\pm 0.04$; $h_{s+d}^2=0.35\pm 0.02$
	Between progeny within dams	968	21909897	22634.19	

Table 6

Analyses of variance Table in the heritability of age at first egg in N and P strains

Strain	Sources	d.f.	SS	MS	heritabilities		
N Strain	Between sires	84	36265	431.726	$h_s^2=0.20\pm 0.00$	$h_d^2=0.22\pm 0.03$	$h_{s+d}^2=0.21\pm 0.00$
	Between dams within sires	324	57026	176.006			
	Between progeny within dams	1724	239988	139.285			
P Strain	Between sires	88	175707	1996.670	$h_s^2=0.06\pm 0.00$	$h_d^2=-0.11\pm 0.04$	$h_{s+d}^2=0.00\pm 0.02$
	Between dams within sires	289	454389	1572.280			
	Between progeny within dams	1063	1815407	1707.815			

Table 7

Analyses of Variance Table in the heritability of egg weight in N and P strains

Strain	Source	d.f.	SS	MS	heritabilities
N Strain	Between sires	84	4383	52.179	$h_s^2 = 0.43 \pm 0.00$
	Between dams within sires	309	5224	16.906	$h_d^2 = 0.62 \pm 0.03$
	Between progeny within dams	1388	13208	9.516	$h_{s+d}^2 = 0.52 \pm 0.01$
P Strain	Between sires	86	4451	51.756	$h_s^2 = 0.28 \pm 0.01$
	Between dams within sires	276	6583	23.852	$h_d^2 = 0.95 \pm 0.04$
	Between progeny within dams	900	11128	12.364	$h_{s+d}^2 = 0.61 \pm 0.02$

in N and P strains are given as Table 8, 9 and 10 and the correlations are given in Table 11 and 12.

All the sire component genetic correlations among the four traits in N strain were greater than 1 and those for P were less than 1 for 40 weeks body weight and egg weight and that between age at first egg and egg weight. The dam component genetic correlations were 0.50, -0.75, 0.13, -0.21, 0.23 and 0.08 for N strain for 20 weeks body weight with 40 weeks weight, age at first egg and egg weight; 40 weeks weight with age at first egg and egg weight and that between age at first egg and egg weight. The dam component genetic correlations for P strain could not be estimated due to the negative variance for 20 weeks body weight and age at first egg. The corresponding correlation between 40 weeks body weight and egg weight is 0.06 for P strain. The sire + dam component genetic correlations in general did not yield any sensible result.

The environmental correlations were 0.31, 0.38 and 0.34 between 20 weeks body weight and 40 weeks body weight; $\angle$-1 and -0.32 between 20 weeks body weight and age at first egg (based on sire and dam components); -0.43, 0.05, -0.21 between 20 weeks body weight and egg weight; 0.50, -0.04

<u>Table 8</u>

Analyses of Covariance Table for correlations of 20 weeks body weight with 40 weeks body weight and age at first egg in N Strain and P Strain

Strain		N strain			P strain		
Combinations	Source	d.f.	SS	MS	d.f.	SS	MS
20 weeks body weight and 40 weeks body weight	Between sires	84	-573145229	-6823157.3	86	-17352315	-201771.1
	Between dams within sires	314	3269079	10411.079	285	3116558	11012.572
	Between progeny within dams	1527	9518224	6233.284	968	8835282	9127.3574
20 weeks body weight and age at first egg	Between sires	84	-23782560	-283125.71	88	-14258637	-162029.96
	Between dams within sires	314	-285277	-880.4846	289	-197235	-682.474
	Between progeny within dams	1723	-900035	-522.3651	1063	-346129	-325.615

Table 9

Analyses of Covariance Table in correlation estimates between 20 weeks body weight and egg weight and 40 weeks body weight and age at first egg in N and P strains

Strain		N Strain			P Strain		
Combinations	Source	d.f.	S.S.	M.S.	d.f.	SS	MS
20 weeks body weight and egg weight	Between sires	84	-28699736	-341663.52	86	-15704083	-182605.61
	Between dams within sires	309	16713	54.087	276	36085	130.743
	Between progeny within dams	1388	34314	24.722	900	80236	89.151
40 weeks body weight and age at first egg	Between sires	84	-1924440	-22910	86	-43025584	-500297.48
	Between dams within sires	313	-77335	-247 .007	282	-52482	-186.106
	Between progeny within dams	1487	-169755	-114.159	940	-51573	-54.865

Table 10

Analyses of Covariance Table in correlation estimates between 40 weeks body weight and egg weight and between age at first egg and egg weight in N and P strains

Strain		N Strain			P Strain		
Combinations	Source	d.f.	SS	MS	d.f.	SS	MS
40 weeks body weight and egg weight	Between sires	84	-15318487	-182362.94	86	-6928961	-80569.313
	Between dams within sires	308	38642	125.461	276	28826	104.442
	Between progeny within dams	1361	76899	56.502	894	79540	88.97
Age at first egg and egg weight	Between sires	84	-3446699	-41032.13	86	-2016616	-23449.023
	Between dams within sires	308	1399	4.542	275	-1268	-4.611
	Between progeny within dams	1366	13208	9.67	878	11128	12.674

Table 11

Genetic, phenotypic and environmental correlations among the traits in N strain

Strain	Combinations	r_{Gs}	r_{Gd}	r_{Es}	r_{Ed}	r_{Es+d}	r_P
N Strain	20 weeks body weight and 40 weeks body weight	>1	0.50	0.31	0.38	0.34	0.34
	20 weeks body weight and age at first egg	>1	-0.75	∠-1	-0.32	-	-0.09
	20 weeks body weight and egg weight	>1	0.13	-0.43	0.05	-0.21	0.23
	40 weeks body weight and age at first egg	>1	-0.21	0.50	-0.04	-0.29	0.08
	40 weeks body weight and egg weight	>1	0.23	-0.31	0.09	-0.12	0.28
	Age at first egg and egg weight	>1	0.08	-0.43	0.09	-0.18	0.25

Table 12

Genetic, phenotypic and environmental correlations among the traits in P strain

Strain	Combinations	r_{Gs}	r_{Gd}	r_{Es}	r_{Ed}	r_{Es+d}	r_{P}
P Strain	20 weeks body weight and 40 weeks body weight	>1	-	-0.09	0.31	0.11	0.47
	20 weeks body weight and age at first egg	>1	-	-0.12	-0.00	-0.06	-0.02
	20 weeks body weight and egg weight	>1	-	-0.40	0.31	-0.17	0.32
	40 weeks body weight and age at first egg	>1	-	-0.54	-0.01	0.24	-0.24
	40 weeks body weight and egg weight	<-1	0.06	0.54	0.29	0.42	0.05
	Age at first egg and egg weight	<-1	-	-0.84	0.04	0.51	-0.32

and -0.29 between 40 weeks body weight and age at first egg; -0.31, 0.09 and -0.12 between40 weeks body weight and egg weight and -0.43, 0.09 and -0.18 between age at first egg and egg weight based on sire, dam and sire + dam components respectively for N strain. The respective environmental correlations for P strain based on sire, dam and sire + dam components were -0.09, 0.31, 0.11; -0.12, -0.00, -0.06; -0.40, 0.31, -0.17; -0.54, -0.01, 0.24; 0.54, 0.29, 0.42 and -0.84, 0.04 and 0.51.

The phenotypic correlations were 0.34, -0.09, 0.23, 0.08, 0.28 and 0.25 for N strain between 20 weeks body weight and 40 weeks body weight, 20 weeks body weight and age at first egg, 20 weeks body weight and egg weight, 40 weeks body weight and age at first egg, 40 weeks body weight and egg weight and between age at first egg and egg weight respectively. The corresponding correlations for P strain were 0.47, -0.02, 0.32, -0.24, 0.05 and-0.32 respectively.

Discussion

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DISCUSSION

It can be observed from Table 2 that the body weights at 20 weeks and 40 weeks of age are higher in P strain than those in N strain. Age at first egg is found to be higher in N strain. The 't' test showed that these differences are highly significant ($P \angle 0.01$). With regard to egg weight no such difference was observed between the two strains. Coefficient of variation worked out for various traits in P as well as N strain revealed higher variability in P strain compared to N strain in all the traits, especially in age at first egg (26.3 per cent). On perusal of the results it was found that hatch-1 showed 47 per cent variation in P strain which had been responsible for the higher value for overall coefficient of variation in P strain.

Least squares analysis was carried out for all the traits viz., 20 weeks body weight, 40 weeks body weight, age at first egg and egg weight, to estimate the hatch effect on these traits. The analysis of variance in Tables 3a and 3b showed significant effect of hatch on all the traits except on egg weight. This effect may be due to the differences in environment such as frequent weather changes, the chicks had to face after hatch. This finding leads to the assumption that environmental fluctuations do not affect egg weight as much as the other characters. The effect of hatch on body weights at 20 weeks and 40 weeks of age, age at first egg and egg weight was reported by Chaudhari et al. (1976) in White Leghorns and on age at sexual maturity and egg weight by Mishra et al. (1978) in Rhode Island Reds and on 20 weeks body weight and 40 weeks body weight in White Leghorns by Natarajan (1977).

The constants for ten hatches of body weight at 20 weeks in N strain varied from -80.4 (hatch - 4) to +69.35 (hatch - 7). It was of interest to note that the very same hatches had the highest (+13.04) and lowest (-7.41) constants for age at first egg, which gave an indication that the environment responsible for lower body weight at 20 weeks of age resulted in delayed maturity in birds and vice versa. In P strain also, the trend was similar. In both N and P strains the higher constants observed for body weight at 40 weeks coincided with higher constants for age at first egg. This shows that the birds starting laying eggs at an early age are lighter at 40 weeks compared to those commencing production at a later stage.

Heritability estimates

(a) Body weight at 20 weeks of age

The estimate of heritability, 0.36 by dam component of variance had been slightly higher than the estimate of 0.25 by sire component in N strain. A meaningful value for heritability in P strain was obtained only by sire component of variance. These estimates came close to 0.43 and 0.32 reported by Krueger <u>et al.</u> (1952) based on twice the full-sib correlation and regression of progeny on dam method, 0.24 by Patel and Rathnasabapathy (1979) and 0.20 by half-sib analysis reported by Natarajan and Rathnasabapathy (1978) for 20 weeks body weight, in White Leghorns.

The higher dam component heritability can be attributed to the possible effect of maternal influence and/or non-additive gene actions on this trait. Hazel and Lamoreux (1947) reported that 5 per cent of the variation in body weight at 22 weeks of age was due to maternal effects in White Leghorns.

(b) Body weight at 40 weeks of age

The heritability estimate for body weight at 40 weeks of age were 0.22, 0.50 and 0.36 for sire, dam and sire + dam components respectively in N strain while these estimates were 0.44, 0.27 and 0.35 respectively for P strain. The estimates are somewhat in accordance with 0.45 from dam-daughter regression method, reported by Hogsett and Nordskog (1958). The heritability of body weight at 40 weeks (0.36) is found to be higher than that at 20 weeks (h^2_{s+d}=0.31). A higher heritability in body weight at 40 weeks may be due to the greater resistance, the birds have, than the younger birds to the environmental stresses. Another possibility that can be attributed to this observation is that maternal effect on body weight is more in older birds than chicks. VanVleck et al. (1963) found 3 per cent maternal effect variance for body weight in chicks and 8 per cent for 32 weeks body weight. Similar observation was made by Ipe (1972) who reported a higher heritability of 0.302 for body weight at 16 weeks of age compared to 0.256 for 6 weeks body weight.

(c) Age at first egg

The estimates of heritability in N strain were found to be 0.20, 0.22 and 0.21 for sire, dam and sire + dam components respectively and the heritability estimates in P strain were not different from zero. In P strain, in general, the per cent overall variability was more ie. 26.3 per cent compared to 8.5 per cent in N strain. On perusal of hatchwise coefficient of variation, it was seen that one hatch had extreme variability (CV = 47 per cent). Even though adjustment with Least squares constants was expected to reduce the environmental variance, thereby increasing the proportion of genetic variance it is to be thought that in this particular case there had been some over-adjustment and genetic variance was completely reduced giving a heritability not different from zero.

The estimates obtained in N strain are in agreement with those of 0.20 by Kruger (1953), 0.26 by King and Henderson

(1954), 0.284 by Tandon et al. (1968) and 0.278 by Ipe (1972) in White Leghorns. However, higher estimates have been reported for age at first egg by Osborne (1954a) and Yamada (1958). Lower estimate of 0.09 has been reported by Onishi (1954a), in White Leghorns, comparable to the estimates of heritability in P strain of this study.

(d) Egg weight

Heritability estimates by dam component of variance were higher (0.62 and 0.95) than, those by sire component (0.43 and 0.28) in this study. The difference between sire and dam component heritabilities can possibly be attributed to maternal effect and/or non-additive gene action. Even if maternal effect variance is of small quantity the multiplicative factor of four in the estimation of heritability is likely to bring in an exaggerated figure, as seen in P strain. These findings of higher heritabilities by dam component of variance in this study very well agree with the reports of Malik and Singh (1967) and Kovalenko and Kosenko (1971) in White Leghorns.

The estimates by full-sib correlation method gave similar results in both strains. These estimates are in accordance with those reported by Jerome et al. (1956) in New Hampshires and Kinney et al. (1968) in White Leghorns. The former reported an estimate of 0.57 while the latter reported 0.52 as the heritability estimate for egg weight. Mohapatra and Ahuja (1971) on the basis of paternal half-sib correlation reported

0.65 as the estimate of heritability for egg weight in White Leghorns. However, lower estimates of 0.22 and 0.25 have been reported by Ipe (1979) and Orlov and Zlocevskaja (1967) respectively in White Leghorns.

In N strain, for all the four characters, dam component of heritability was found to be higher than that by sire component of variance. A slightly higher estimate of heritability due to dam component of variance gave an indication that the traits were possibly influenced by maternal effects and/or dominance deviation. Heritability of all the traits had been moderate and the highest heritability had been for egg weight. In P strain, evidence for maternal influence and/or non-additive gene action was not observed with regard to body weights at 20 weeks and 40 weeks and age at first egg. Heritability by paternal half-sib correlation method is considered to be more reliable as it is free from maternal effect and dominance deviations. As the data used, had been large and the standard error of the estimates very low, it can be concluded that the estimates obtained are quite reliable. The estimates by sire component of variance can be used more confidently in predicting the possible response to selection. From the magnitude of heritability of these traits, though moderate, it can be concluded that selection for the traits especially age at first egg and egg weight which have more economic importance can be continued in the population for some more generations.

Correlations

Genetic correlation by sire component between the four traits studied exceeded the theoritical limit in both N and P strains. Therefore the genetic correlations based on dam-component of covariance, were considered and discussed.

(a) Body weights at 20 weeks and 40 weeks

The estimates presented in Table 11 and Table 12 indicated that genetic, phenotypic and environmental correlations between body weights at 20 weeks and 40 weeks of age are positive in both the strains. A similar observation was made in White Leghorns by Natarajan (1977) and Yamada (1955) between body weight at maturity and mature body weight in White Leghorns.

(b) Body weight at 20 weeks and age at first egg

Genetic correlation by dam component of covariance had been negative as against the positive correlation by sire component of covariance. The difference is possibly due to maternal effects and/or dominance deviations. The environmental correlation (-0.32) had been negative indicating that an environment causing higher body weight at 20 weeks resulted in lower age at first egg. The phenotypic correlation had been almost zero. King (1961) has expressed the view that correlations by sire and dam components of covariance could be of different sign and magnitude. Negative genetic correlation has been reported by Ahlawat *et al.* (1980) between 20 weeks body weight and age at sexual maturity in White Leghorns. However, Dickerson (1957) reported a positive genetic correlation of 0.29 between body weight at 18 weeks and age at first egg. Negative environmental and phenotypic correlations have been reported by Dickerson (1957) and Merritt (1968) between body weight and age at first egg. From these observations it could be concluded that by increasing body weight at 20 weeks, age at first egg could be reduced which in turn might help to produce more number of eggs during life time.

(c) Body weight at 20 weeks and egg weight

In N strain genetic correlation between body weight at 20 weeks and egg weight was 0.13 by dam component. Though sire component correlation was also positive the magnitude was higher. In P strain meaningful results were not obtained. Ipe and Varkey (1980) reported 0.29 of genetic correlation between pullet weight and egg weight in White Leghorns. But the genetic correlation of -0.30 was reported by Hurnik (1965) between egg weight and body weight in White Leghorns. Environmental correlation and phenotypic correlation showed similar trend in both strains. Environmental correlation ($r_{E_{s+d}}$) was -0.21 and -0.17 in N and P strains respectively while phenotypic correlations in these two strains were 0.23 and 0.32 respectively. Hurnik (1965) reported 0.10 as the phenotypic correlation between egg weight and body weight in White Leghorns.

(d) Body weight at 40 weeks and age at first egg

In N strain, genetic correlation by dam component was found to be -0.21 while the correlation by sire component was greater than one. The environmental correlation was -0.29 and the phenotypic correlation was not different from zero in N strain. King (1961) reported 0.04 as the phenotypic correlation between age at sexual maturity and 32 weeks body weight in White Leghorns.

(e) Body weight at 40 weeks and egg weight

In N strain, genetic and phenotypic correlation between body weight at 40 weeks and egg weight were 0.23 and 0.28 respectively and environmental correlation did not differ from zero.

(f) Age at first egg and egg weight

In N strain, the phenotypic correlation between age at first egg and egg weight was 0.25 while the genetic correlation by dam component was almost zero. The estimates are in accordance with 0.18 the genetic correlation between egg weight and age at sexual maturity in White Leghorns reported by Chung (1977).

Between body weights, all the genetic, phenotypic and environmental correlations were positive in N strain. Genetic correlations of body weights with age at first egg had been negative and with egg weight positive. Between age at first egg and egg weight, genetic correlation was almost zero.

It could be considered that the genes responsible for growth continued to exert their action on body weight at later part of the life. It is possible that some of the genes responsible for higher body weights are pleiotropic and they favourably influence maturity as well as egg weight.

The correlations between traits indicated that while attempting improvement, the interrelationship of traits should be taken into consideration. Genetically, the body weights are negatively correlated with age at first egg and positively with egg weight. It was further seen that an environment which causes a higher pullet body weight brings in early maturity.

SUMMARY

The data pertaining to S and F strains of White Leghorn maintained at the Poultry Farm under the All India Co-ordinated Research Project on Poultry for Eggs during the period from 1979-1983 were analysed for body weights at 20 weeks and 40 weeks of age, age at first egg and egg weight. Observations on 2532 progenies produced out of 55 sires and 412 dams in S strain and 1914 progenies produced out of 59 sires and 385 dams in F strain were utilized for the study.

The averages for the body weights (g) at 20 weeks and 40 weeks, age at first egg (days) and egg weight (g) were 1135.5 ± 3.4, 1437.0 ± 4.0, 166.0 ± 0.50 and 51.7 ± 0.10 for S strain and 1240.0 ± 5.4, 1518.6 ± 5.7, 162.1 ± 1.1 and 51.7 ± 0.10 for F strain respectively. Body weights of birds in S strain were significantly lower than those of F strain, whereas age at first egg was significantly higher in S strain. However, no difference was observed for egg weight between two strains.

Least squares analysis of variance revealed significant effect of hatches on body weights at 20 weeks and 40 weeks and age at first egg in both strains. The heritability estimates were calculated using paternal half-sib, maternal half-sib and full-sib correlation methods for all the traits in both the strains.

In S strain, the heritability estimates based on sire, were

SUMMARY

The data pertaining to N and P strains of White Leghorn maintained at the Poultry Farm under the All India Co-ordinated Research Project on Poultry for Eggs during the period from 1979-1980 were analysed for body weights at 20 weeks and 40 weeks of age, age at first egg and egg weight. Observations on 2259 progenies produced out of 85 sires and 412 dams in N strain and 1514 progenies produced out of 89 sires and 383 dams in P strain were utilized for the study.

The averages for the body weights (g) at 20 weeks and 40 weeks, age at first egg (days) and egg weight (g) were 1181.5 ± 2.8, 1457.0 ± 4.0, 166.0 ± 0.30 and 51.7 ± 0.10 for N strain and 1245.9 ± 5.4, 1518.6 ± 5.7, 162.1 ± 1.1 and 51.7 ± 0.10 for P strain respectively. Body weights of birds in N strain were significantly lower than those of P strain, whereas age at first egg was significantly higher in N strain. However, no difference was observed for egg weight between two strains.

Least squares analysis of variance revealed significant effect of hatches on body weights at 20 weeks and 40 weeks and age at first egg in both strains. The heritability estimates were calculated using paternal half-sib, maternal half-sib and full-sib correlation methods for all the traits in both the strains.

In N strain, the heritability estimates based on sire, dam

and sire + dam components of variance were 0.25 ± 0.00, 0.36 ± 0.01, 0.31 ± 0.01 for body weight at 20 weeks; 0.22 ± 0.00, 0.50 ± 0.03, 0.36 ± 0.00 for body weight at 40 weeks; 0.20 ± 0.00, 0.22 ± 0.03, 0.21 ± 0.00 for age at first egg and 0.43 ± 0.00, 0.62 ± 0.03 and 0.52 ± 0.01 for egg weight respectively. The corresponding estimates in P strain were 0.25 ± 0.02, -0.19 ± 0.12, 0.03 ± 0.04 for body weight at 20 weeks; 0.44 ± 0.00, 0.27 ± 0.04, 0.35 ± 0.02 for body weight at 40 weeks; 0.06 ± 0.00, -0.11 ± 0.04, -0.00 ± 0.02 for age at first egg and 0.28 ± 0.01, 0.95 ± 0.04 and 0.61 ± 0.02 for egg weight respectively.

From the estimates of N strain, it can be concluded that maternal effect and/or non-additive gene action play a role in the inheritance of these traits. The estimates made in P strain revealed no evidence for maternal and/or non-additive gene action for these traits.

The genetic correlations were positive between body weights at 20 weeks and 40 weeks and between body weights and egg weight, negative between body weights and age at first egg and positive between age at first egg and egg weight. Environmental and phenotypic correlations between the traits under study were generally of low magnitude. The genes responsible for growth might, perhaps, continue to exert their action on body weight during later part of the life. The genes for higher body weights might be pleiotropic and might favourably influence maturity as well as egg weight.

From the magnitude of heritability of these traits, though moderate, it can be concluded that selection for the traits especially age at first egg and egg weight which have more economic importance can be continued in the population for some more generations. The correlations between traits indicate that while attempting for improvement, the inter-relationship of traits should be taken into consideration. Genetically the body weights are negatively correlated with age at first egg and positively with egg weight. It was further seen that an environment which causes a higher pullet body weight brings in early maturity.

References

REFERENCES

Abdel - Gawad, E.M. and El - Ibiary, H. (1971). Heritability estimates of productive traits in the Fayoumi, Leghorns and Rhode Island Red Chickens. 2. Egg production traits. Agri. Res. Rev. 49(4) : 79-86.

Acharya, R.M., Dhillon, J.S. and Tiwana, M.S. (1969). Age at first egg and egg production - their inheritance and expected response to different methods of selection. Br. Poult. Sci. 10 : 175 - 181.

Aggarwal, C.K. (1970). Phenotypic correlations of some economic traits in White Leghorn pullets. Indian Vet. J. 47 : 34 - 43.

Ahlawat, S.P.S. and Chaudhary, R.P. (1981). The influence of a long hatching season on growth and production traits in a commercial strain of White Leghorn chickens. Indian Poult. Gaz. 65(2) : 62 - 65.

Ahlawat, S.P.S., Chaudhary, R.P. and Singh, B.P. (1980). Genetic and phenotypic correlation for some productive traits in the Babcock strain of White Leghorn. Indian Poult. Gaz. 64 (1) : 28 - 34.

Arthur, J.A. and Beck, N.J. (1974). Linear estimates of heritabilities and genetic correlations for body weight, egg weight and shell colour in chickens. Anim. Breed. Abstr. (1975) : 43 (5) : 2019.

Auxilia, M.T. and Mastrorillo, C. (1965). Relationship between egg weight and hatchability. Anim. Breed. Abstr. 33 (3) : 2928.

Baczkowska, H., Kamiriska, B. and Treundlich, A. (1963). Studies on the heritability of some characters of economic importance in laying hens based on maternal from two breeding farms. Cited from Anim. Breed. Abstr. (1964) 32 (4) : 3412.

Banerjee, A.K., Desai, R.N. and Chaudhary, R.P. (1976). Inheritance of some economic traits in White Leghorn selected for egg production. Indian J. Anim. Sci. 46 (5) : 249 - 253.

Becker, W.A. (1975). Manual of procedures in quantitative genetics. Washington State University, Pullman, Washington.

Blyth, J.S.S. (1952). The correlation between egg number and egg weight in the fowl. An investigation of its inconstancy. Poult. Sci. 31 (2) : 254 - 268.

Casey, D.W. and Nordskog, A.W. (1971). Effect of selection for body weight, egg weight and heterogygosis in laying house performance. Poult. Sci. 50(4) : 999 - 1008.

Chand, O., Georgis, G.C. and Razdan, M.N. (1976). Effect of two different housing conditions on the body weights, meat quality and weights of internal organs of White Leghorn males. Indian J. Poult. Sci. 11 (2) : 86 - 90.

Chaudhari, D., Mohapatra, S.C., Venkatramaiah, A., Ayyagasi, V. and Ahuja, S.D. (1976). Genetic variation and covariation for some of the economic traits in four White Leghorn strains. Indian J. Poult. Sci. 11 (4) : 189 - 197.

Chung, S.B. (1977). Study on the estimate of linear heritabilities and genetic correlations on economic traits of laying hens. c.f. Anim. Breed. Abstr. (1979) 47 (11) : 6388.

Crittenden, L.B. and Bohren, B.B. (1961). The genetic and environmental effects of hatching time, egg weight and holding time on hatchability. Poult. Sci. 40(60): 1736 - 1749.

Dickerson, G.E. (1957). Genetic variation among some economic characters of Leghorn-type chickens. Poult. Sci. 36 : 1112.

Festing, M.F. and Nordskog, A.W. (1967). Response to selection for body weight and egg weight in chickens. c.f. Anim. Breed. Abstr. 35 (3) : 3029.

Galvano, G. (1968). Observation on the relationship of egg weight and quantity with body weight and age of hens. Anim. Breed. Abstr. (1970) 38 (2) : 1921.

Gleichauf and Mehnert, M. (1956). Testing a Leghorn flock for performance. Anim. Breed. Abstr. (1958) 26 (1) : 427.

Godfrey, G.F., Williams, C. and Marshall, C.E. (1953). The relative influence of egg size, age at sexual maturity and mature body weight on growth to 12 weeks of age. Poult. Sci. 32 (3) : 496 - 500.

Gruev, V., Conkov, C. (M). and Nozeev, S. (V). (1964). Correlations between egg weight and some other characters of stara Zagorsk Red hens. Anim. Breed. Abstr. (1965) : 33 (1) : 723.

Gruhn, R. and Wendt, H. (1963). Heritability estimates for various components of egg production in White Leghorns. Anim. Breed. Abstr. (1964) 32 (2) : 1527.

Gurung, B.S. and Taylor, C.M. (1978). Genetic analysis of egg weight of White Leghorn. Cited from Anim. Breed. Abstr. (1979) 47 (8) : 4540.

Gurung, B.S. and Taylor, C.M. (1981). Studies on age at sexual maturity in White Leghorn. Poultry Adviser 19 (1) : 29 - 30.

Han, S.W. and Ohh, B.K. (1975). Heritabilities and genetic correlations of egg weight increase and other egg production traits in laying fowls. Korean J. Anim. Sci. 17(1) : 15 - 45.

Harvey, W.R. (1966). Least squares Analysis of Data A.R.S. 20 - 8. United States Department of Agriculture.

Hays, F.A. (1924). Inbreeding in the Rhode Island Red fowl with special reference to winter egg production. Cited from Poultry Breeding (1962) 3rd ed. John Wiley and Sons, INC, New York.

Hays, F.A. (1940). Correlations in egg weight between mothers and daughters. J. Hered. 31 : 476.

Hays, F.A. (1951). The relation of age at sexual maturity to some developmental characters. Poult. Sci. 30 (5): 723 - 726.

Hays, F.A. (1952). Effects of age at sexual maturity on body weight and egg production. Poult. Sci. 31 (6) : 1050 - 1052.

Hazel, L.N. and Lamoreux, W.F. (1947). Heritability, maternal effects and nicking in relation to sexual maturity and body weight in White Leghorns. Poult. Sci. 26(5) : 508 - 514.

Henderson, E.W. (1954). Inheritance of egg weight among parents and progeny of a Dark - Cornish - White Leghorn reciprocal cross. Cited from Anim. Breed. Abstr. 22(4): 1769.

Henderson,E.F. (1962). Inheritance of egg weight not affected by sex-linked genes. Cited from Anim. Breed. Abstr. 30(4) : 2859.

Hicks,A.F. (1958). Heritability and correlation analyses of egg weight, egg shape and egg number in chickens. Poult. Sci. 37(4) : 967 - 974.

Hill,A.T., Kreuger,W.F. and Quisenberg,J.H. (1966). A biometrical evaluation of component parts of eggs and their relationship to other economically important traits in a strain of White Leghorns. Poult. Sci. 45 : 1162 - 1185.

Hogsett,M.L. and Nordskog,A.W. (1958). Genetic - economic value in selecting for egg production rate, body weight and egg weight. Poult. Sci. 37(5): 1404 - 1419.

Hurnik,J. (1963). The heritability of some productive characters in poultry. Cited from Anim. Breed. Abstr. (1964) 32 (1) : 577.

Hurnik,J. (1965). Correlations between economic characters in poultry. Cited from Anim. Breed. Abstr. 33 (3): 2858.

Husain,K.Q. and Singh,S.N. (1964a). A study on inheritance of some economic characters and their relative importance for selection in White Leghorn breed. Indian vet. J. 41 (7): 478 - 485.

Husain,K.Q. and Singh,S.N. (1964b). A study on inheritance of some economic characters and their relative importance for selection in White Leghorn breed. Cited from Anim. Breed. Abstr. (1965) 33 (2) : 1733.

Hussaini,S.S.H. and Das,S. (1971). Heritability of age and body weight at first egg in White Leghorns. Indian vet. J. 48 : 503 - 507.

Hussaini,S.S.H. and Rizvi,A.H. (1972). Effect of date of hatch on age at first egg in White Leghorn pullets. Indian vet. J. 49 (7) : 678 - 681.

Ignatov,S., Nozhchev,S., Kunev,K. and Dimitrov,D. (1975). Heritability and genetic correlations of some principal production characters of four lines of White Leghorn hens. Cited from Anim. Breed. Abstr. (1977) 45 (9): 5661.

Ipe,S. (1972). Genetic studies on Forsgate strain of White Leghorn. M.V.Sc. Thesis, U.P. College of Veterinary Science and Animal Husbandry, Mathura.

Ipe,S. (1979). Inheritance of egg weight in Forsgate strain of White Leghorns. Kerala J. vet. Sci. 10 (1) : 71 - 74.

Ipe,S. and Singh,B.P. (1979). Genetic architecture of a White Leghorn population. Indian vet. J. 56(10): 849 - 854.

Ipe,S. and Varkey,A.C. (1980). Association of egg weight with chick weight, pullet weight and egg number in a synthetic White Leghorn population. Indian J. Poult. Sci. Abstr. 15 (1) : 13 - 37.

Iqbaluddin, Chaudhary,R.P. and Sharma,R.P. (1975). Influence of full-sib mating in White Leghorn pullets on their production traits. Indian J. Hered. 7 (1) : 47 - 58.

Jain,R.S., Banerjee,A.K. and Chaudhary,R.P. (1980). Genetic studies on production traits in White Leghorn. Indian vet. J. 57 (8) : 671 - 675.

Jayanna,A.S., Likanath,G.R. and Ramappa,B.J. (1980). Genetic architecture and efficiency of selection index for multiple traits in Mychix strain in White Leghorn. Indian J. Poult. Sci. Abstr. 15 (1) B.35

Jerome,F.N., Henderson,C.R. and King,S.C. (1956). Heritabilities, gene interactions and correlations associated with certain traits in the domestic fowl. Poult. Sci. 35 : 995 - 1013.

Johari,D.C, Dutt,M. and Husain,K.O. (1977). Genetic and phenotypic correlation for some traits of economic importance in a strain of White Leghorn. Indian J. Poult. Sci. 12 (11): 17 - 20.

Kaatz,C. (1972). Heritability and genetic correlations of various egg production characters and body weight in two strains of broiler. Cited from Anim. Breed. Abstr. (1973) 41 (2) : 5543

Kaszvica,E., Czarnecka,J., Gancarczyk,B. and Przyborska,H. (1968). Genetic parameters relating to Leghorn fowls. Cited from Anim. Breed. Abstr. (1971) 39(1) : 1137.

Kawahara, T. (1965). Variance and Covariance analysis of egg weight, egg shape and body weight in domestic fowl. Cited from Anim. Breed. Abstr. (1966) 34 (3): 2529.

Kawahara, T. and Inoue, T. (1966). Variance and covariance analysis of egg production and related characters in the domestic fowl. Cited from Anim. Breed. Abstr. (1967) 35 (3): 3041.

King, S.C. (1961). Inheritance of economic traits in the Regional Cornell Control population. Poult. Sci. 40 (4) : 975 - 985.

King, S.C. and Bruckner, J.H. (1952). A comparative analysis of pure-bred and cross-bred poultry. Poult. Sci. 31 (6) : 1030 - 1036.

King, S.C. and Henderson, C.R. (1954). Heritability studies of egg production in the domestic fowl. Poult. Sci. 33 (1): 155 - 168.

Kinney, T.B., Bohren, B.B., Craig, J.V. and Lowe, P.C. (1970). Responses to individual, family and index selection for short term rate of egg production in chickens. Poult. Sci. 49 (4) : 1052 - 1064.

Kinney, T.B., Lowe, P.C., Bohren, B.B. and Wilson, S.P. (1968). Genetic and phenotypic variation in random bred White Leghorn controls over several generations. Poult. Sci. 47 : 113 - 123.

Kolstad, N. (1971). Genetic parameters for a poultry selection index. Cited from Anim. Breed. Abstr. (1973) 41 (6) 2881.

Kosha, M.A., Shawer, M.F. and El - Ibiary, H.M. (1977). Selection for age at sexual maturity in chickens under different mating systems. Cited from Anim. Breed. Abstr. (1978) 46 (1) : 495.

Kovalenko, A.T. (1970). Heritability and variability of egg weight and shape indices in egg lines of fowls. Cited from Anim. Breed. Abstr. (1972) 40 (1) : 1067.

Kovalenko, V.P. and Kosenko, N.F. (1971). Heritability and phenotypic and genetic correlations and regressions for basic selected traits in fowls from specific lines. Cited from Anim. Breed. Abstr. 39 (3) : 3986.

Krishna, S.T. and Chaudhary, R.P. (1972a). Heritability of body weight in White Leghorn. J. Anim. Sci. 42 (5): 373 - 377.

Krishna, S.T. and Chaudhary, R.P. (1972b). Sources of variation in body weight of White Leghorn. Indian vet. J. 49 (8) 795 - 799.

Krueger, W.F. (1953). The heritability of total egg production, its components and body weight and their genetic and environmental relationships, in the domestic fowl. Cited from Anim. Breed. Abstr. 21 (4) : 1933.

Krueger, W.F., Dickerson, G.E., Kinder, Q.B. and Kempster, H.L. (1952). The genetic and environmental relationship of total egg production to its components and to body weight in the domestic fowl. Poult. Sci. 31 : 922.

Krutikova, I.U. (1977). Genetic variation of some characters in egg producing fowls. Cited from Anim. Breed. Abstr. 48 (2) : 859.

Kumar, J. and Acharya, R.M. (1980). Genotypic and phenotypic parameters of egg production and egg quality traits of desi fowl. Indian J. Anim. Sci. 50 (6): 514 - 517.

Kumar, J. and Kapri, B.D. (1966). Genetic studies on internal egg quality and its relationship with other economic traits in White Leghorn birds. Pt. 1. heritability and repeatability of egg quality. Indian vet. J. 43(9): 825 - 829.

Kumar, J. and Kapri, B.D. (1967). Genetic studies on egg quality and its relationship with some of the economic traits in White Leghorn birds. Part III. Economic traits. Indian vet. J. 44 (10): 847 - 851.

Kumar, J. and Kapri, B.D. (1968). Genetic studies on internal egg quality and its relationship with other economic traits in White Leghorn birds. IV. Relationship of egg size with egg quality and other economic traits. Indian vet. J. 45 : 943 - 947.

Kumar, J. and Mohan, M. (1972). Genetic and phenotypic variation in some of the economic traits of White Leghorn chicks. Indian J. Anim. Prod. 2 (4) : 31 - 36.

Lerner, I.M. and Cruden, D. (1951). The heritability of egg weight, the advantages of mass selection and of early measurements. Poult. Sci. 30(1) : 34 - 40.

Lowe, R.W. and Heywang, B.W. (1964). Effect of various light treatments during growing period on egg production of October hatched White Leghorn pullets. Poult. Sci. 43 (1) : 11 - 15.

Mann, R.S. (1980). Genetic evaluation of economic traits in poultry. Cited from Anim. Breed. Abstr. (1981) 49 (10) : 6090.

Malik, D.D. and Singh, R. (1967). Heritability estimates of certain economic egg traits of a White Leghorn population. Cited from Anim. Breed. Abstr. (1968) 36 (1) : 867.

Manson, J.M. (1973). Genetic change in the egg weight, body weight association in the fowl. Br. Poult. Sci. Limited : 247 - 256.

Merritt, E.S. (1968). Genetic parameter estimates for growth and reproductive traits in a random-bred control strain of meat type fowl. Poult. Sci. 47 : 190.

Midtid, S. (1953). Genetical researches on the egg yield of White Leghorns. Cited from Anim. Breed. Abstr. (1954) 22 (4) : 1775.

Mishra, M.C., Jain, G.L., Pani, S.N. and Mohanty, B.K. (1978). Heritabilities and genetic correlations of some economic traits in Rhode Island Red flock. Indian J. Poult. Sci. 13 (1) : 35 - 38.

Mohapatra, S.C. and Ahuja, S.D. (1971). Selection for egg production in a flock of White Leghorn. II. Response in the secondary traits and their heritabilities. III. Genetic, phenotypic and environmental correlations between selected and unselected traits. Indian J. Poult. Sci. 6(2): 17 - 22.

Mostageer, A. and Kamar, G.A.R. (1961). On the inheritance of egg weight. Poult. Sci. 40(4) : 857 - 860.

Nanda, S.K., Mohapatra, S.C., Ahuja, S.D. and Sharma, P.N. (1973). Consequences of selection based on an index with egg production, egg weight, egg and body weight at sexual maturity in chickens. Indian J. Poult. Sci. 8 (4) : 264 - 272.

Natarajan, N. (1977). Genetic interrelationship among measurements of body weight of poultry at different ages. IndianPoult. Gaz. 61 (4) : 146 - 150.

Natarajan,N. and Rathnasabapathy,V. (1977). Hatch effects on egg production traits in Meyer strain White Leghorn chickens. Indian Poult. Gaz. 61 (3): 85 - 89.

Natarajan,N. and Rathnasabapathy,V. (1978). Correlated responses in egg production traits due to index selection for egg mass. Indian J. Poult. Sci. 13 (2) : 94 - 101.

Natarajan,N. and Rathnasabapathy,V. (1980). Inheritance of egg mass and its relationship with other production traits. Cheiron 9 (1): 27 - 32.

Nikolov,G. and Belorechkov,D. (1978). Genetic analysis of some performance traits in early evaluation of Leghorn pullets. Cited from Anim. Breed. Abstr. (1980) 48 (12) : 7547.

Nikolov,G., Eftikov,S. and Tamarov,S. (1976). Coefficients of heritability and phenotypic, genetic and paratypic correlations for White Leghorn lines 5-A and 6-E. Cited from Anim. Breed. Abstr. 44 (1) : 5400.

Nordskog,A.W. and Briggs,D.M. (1968). The body weight egg production paradox. Poult. Sci. 47 : 498 - 504.

Onishi,N. (1954a). On the inheritance of sexual maturity in Single Comb White Leghorns. Cited from Anim. Breed. Abstr. (1955) 23 (4) : 1921.

Onishi,N. (1954b). On the inheritance of sexual maturity in Single Comb White Leghorns. Cited from Anim. Breed. Abstr. (1955) 23 (1) : 354

Orlov,M.V. and Zlocevskaja,K.U. (1967). Genetic analysis of White Leghorn lines at the state poultry breeding farm "Marx". Cited from Anim. Breed. Abstr. (1968) 36 (3) : 3113.

Osborne,R. (1953). The inheritance of egg weight in the domestic fowl : further evidence of sex-linkage. Poult. Sci. 32 (1) : 60 - 64.

Osborne,R. (1954a). Sexual maturity in Brown Leghorns and the relationship of genetic variance to differences in environment. Cited from Anim. Breed. Abstr. (1956) 24 (2) : 826.

Osborne,R. (1954b). Sex-linked association of egg weight and body weight in Brown Leghorns. Cited from Anim. Breed. Abstr. (1956) 24 (2) : 827.

Osborne,R. (1954b). Sex-linked association of egg weight and body weight in Brown Leghorns. Cited from Anim. Breed. Abstr. (1956) 24 (2) : 827.

Patel,M.M. and Rathnasabapathy,V. (1979). Estimates of genetic correlations between economic traits in Meyer strain of White Leghorn fowls. Cheiron 8 (4): 216 - 219.

Penteado,L.A. (1971). Correlation between body weight and age of pullet at sexual maturity. Cited from Anim. Breed. Abstr. (1972) 40 (4) : 5200.

Pinan,O.F. (1962). Coefficients of heritability for two traits in two strains of White Leghorns. Cited from Anim. Breed. Abstr. (1963) 31 (2) : 2557.

Rao,G.V. and Bose,S. (1967). A study on the normal rate of growth of White Leghorn chicks hatched during different seasons. Indian J. Vet. Sci. 37 (3): 150 - 155.

Rao,G.V.S., Johari,D.C., Dutt,M. and Husain,K.Q. (1977). Heritability estimate of internal egg quality traits in some White Leghorn strains. Indian J. Poult. Sci. 12 (1) : 6 - 8.

Reddy,P.M. (1977). Studies on heritability and genetic correlations of certain economic characters in four different strains of White Leghorns. Cited from Anim. Breed. Abstr. (1980) 48 (3) : 1518.

Reddy,C.V., Prasad,V.L.K., Subbarayudu,P. and Quadeer,M.A. (1972). Studies on phenotypic correlations for some important economic traits in White Leghorn pullets. Indian J. Poult. Sci. 7 (1) : 21 - 27.

Reddy,P.M., Sarma,P.L.N. and Reddy,C.V. (1978). Heritability estimates and genetic correlations among production traits in four White Leghorn strains available in India. Indian J. Poult. Sci. 13 (3) : 151 - 154.

Reutt,R., Ciesielska,K. and Zuk,B. (1966). Application of a new method for estimating the breeding value of cowls. Cited from Anim. Breed. Abstr. (1968) 36 (1) : 873.

Rico,M. (1962). Inheritance of quantitative characters in the species Gallus domesticus.1. heritability of egg production, egg weight and body weight. Cited from Anim. Breed. Abstr. (1964) 32 (3) : 2453.

Roberts,E., Card,L.E., Shakke,W.E. and Waters,N.F. (1952). Inheritance of egg weight. Poult. Sci. 31 (5) : 870 - 874.

Rodero,A., and DeMiguel,M.R. (1961). Heritability of body weight in Black Castilioun, Franciscan Utrera and White Leghorn pullets. Cited from Anim. Breed. Abstr. (1963) 31 (3) : 703.

Saeki,Y. and Katsurag,T. (1957). Several factors affecting egg size especially interrelationship between egg weight and some economic traits. Cited from Anim. Breed. Abstr. (1958) 26(3) : 1606.

Saeki,Y., Sekidera,S., Okawa,Y. and Akita,T. (1966a). Heritabilities and genetic correlations involving certain productive performances expressed in several breeds of chickens. Cited from Anim. Breed. Abstr. (1967) 35 (3) : 3076.

Saeki,Y., Sekidera,S., Okawa,Y. and Akita,T. (1966b). Laying performance and genetic parameters in some breeds of chicken. 1. heritabilities of some economic traits and genetic correlations of laying performance. Cited from Anim. Breed. Abstr. 34 (4) : 3371.

Sandhu,J.S. and Dev,D.S. (1972). Efficiency of selection based on part year egg production. Indian Poult. Gaz. 56 (3) : 83 - 90.

Sarma,P.L.N., Kumar,T.K. and Reddy,C.V. (1977). Production characters of certain White Leghorn strains available in India. Indian J. Poult. Sci. 12 (3) : 28 - 32.

Sharma,M.L. (1978). Genetic studies on some economic traits in White Leghorn and Rhode Island Red chickens. Cited from Anim. Breed. Abstr. (1980) 48 (3) : 1521.

Shibata,K. (1965). Genetic correlations among some economic traits in a White Leghorn closed flock. Cited from Anim. Breed. Abstr. (1966) 34 (3) : 2344.

Singh,B.N., Mukherjee,D.P. and Mati,K.L. (1976). Genetic analysis of production traits in White Leghorn birds (Victoria strain). Indian J. Poult. Sci. 11 (3) : 145 - 149.

Singh,R., Taneja,U.K. and Bhat,P.N. (1972). Inheritance of age at sexual maturity and part egg production in a White Leghorn population. Indian J. Anim. Prod. 2 (4) : 37 - 40.

Sivaswamy,V., Natarajan,N. and Rathnasabapathy,V. (1976). Selection index in Meyer strain White Leghorn pullets. Cheiron 5 (1) : 38 - 41.

Smith,K.P. and Bohren,B.B. (1975). Age of pullet effects on hatching time, egg weight and hatchability. Poult. Sci. 54 (4) : 959 - 963.

Snedecor,G.W. and Cochran,G.C. (1967). Statistical methods (6th ed.). Oxford and IBH Publishing Co.

Tandon,H.P., Rao,G.V. and Lachiramani,R. (1968). Studies on the inheritance of sexual maturity in White Leghorns. Indian vet. J. 45 : 517 - 526.

Tardalbjan,G.A. (1971). Investigation of the relationship between some production characters and egg quality traits in White Leghorn hens in rate of sexual maturity. Cited from Anim. Breed. Abstr. 39 (2) : 2529.

Taylor,C.M., Gurung,B.S. and Vyas,R. (1975). Heritabilities of some of the economic traits in White Leghorn. Cited from Anim. Breed. Abstr. (1976) 44 (12) : 5980.

Thak,T.Y., Chung,S.B. and Sul,D.S. (1975). Studies on heritability and genetic correlations among economic traits in domestic fowl. Cited from Anim. Breed. Abstr. (1977) 45 (10) : 6293.

Tomilova,M.T. (1975). Relationships between some production traits in egg producing types of fowl. Cited from Anim. Breed. Abstr. (1975) 43 (5) : 2013.

Trehan,P.K. and Dev,S. (1974). Efficiency of selection for egg mass. Indian J. Poult. Sci. 9 (1) : 39.

Vanchev,T., Donchev,R., Ignatov,S. and Burzova,I. (1974). Heritabilities, genetic and phenotypic correlations of some principal characters in line 6-E White Leghorns. Cited from Anim. Breed. Abstr. (1975) 43 (9) : 4292.

VanVleck,L.D., King,S.C. and Doolitte,D.P. (1963). Sources of variation in the Cornell controls in two locations. Poult. Sci. 42 : 1114.

Virmani,S.C. and Singh,B.P. (1977). A note on the inheritance of some economic traits in White Leghorn. Indian J. Anim. Sci. 47 (3) : 156 - 158.

Waring, F.J., Hunton, P. and Maddison, A.E. (1962). Genetics of a closed poultry flock. Variance and covariance analysis of egg production, egg weight and egg mass. Br. Poult. Sci. 33 : 151 - 160.

Yamada, Y. (1955). Genetic variation and covariation in economic traits in some breeds of chickens. Cited from Anim. Breed. Abstr. (1956) 24 (2): 835.

Yamada, Y. (1958). Heritability and genetic correlations in economic characters in chickens. Cited from Anim. Breed. Abstr. 26 (4) : 2179.

Yoo, J.S. and Ohh, B.K. (1978). Relationship between body weight at sexual maturity and other economic characters in layers. Cited from Anim. Breed. Abstr. (1979) 47 (9) : 5104.

Yi, L.X. and Ye, Y.S. (1980). A preliminary study of four inherited traits in Qingdao White Leghorns. Cited from Anim. Breed. Abstr. (1981) 49 (2) : 1048.

Zielinski, K. (1959). Correlation between the weight of pullets during the growing period and their age at sexual maturity - White Leghorns. Cited from Anim. Breed. Abstr. (1960) 28 (2) : 954.

Zuk, B. (1969). Heritabilities of some production characters in White Leghorns and correlations between them. Cited from Anim. Breed. Abstr. (1970) 38 (3): 3030.

INHERITANCE OF BODY WEIGHT, EGG WEIGHT AND AGE AT FIRST EGG IN WHITE LEGHORN BIRDS

By

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ABSTRACT OF A THESIS

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ABSTRACT

An investigation was carried out to study the inheritance of body weights, age at first egg and egg weight in White Leghorn birds. The data required for the study were collected from two strains of White Leghorns maintained in the Farm under All India Co-ordinated Research Project for Eggs, Mannuthy.

The Least squares analysis of variance was carried out to find out the effect of hatches on the traits under study. Since the effect of hatch was significant, the data were adjusted for this effect and utilized to estimate heritability, genetic, phenotypic and environmental correlations among body weights and age at first egg. Hatch effect was not significant for egg weight.

The averages for body weights (g) at 20 weeks and 40 weeks, age at first egg (days) and egg weight (g) were 1181.5 ± 2.8, 1457.0 ± 4.0, 166.0 ± 0.30 and 51.7 ± 0.10 for N strain and 1245.9 ± 5.4, 1518.6 ± 5.7, 162.1 ± 1.1 and 51.7 ± 0.10 for P strain respectively.

The heritabilities based on sire, dam and sire + dam components of variance were 0.25 ± 0.00, 0.36 ± 0.01, 0.31 ± 0.01, for body weight at 20 weeks; 0.22 ± 0.00, 0.50 ± 0.03, 0.36 ± 0.00 for body weight at 40 weeks; 0.20 ± 0.00, 0.22 ± 0.03, 0.21 ± 0.00 for age at first egg and 0.43 ± 0.00, 0.62 ± 0.03 and 0.52 ± 0.01 for egg weight respectively. In P strain the respective estimates were 0.25 ± 0.02, -0.19 ± 0.12 and

0.03 ± 0.04 for body weight at 20 weeks; 0.44 ± 0.00, 0.27 ± 0.04 and 0.35 ± 0.02 for body weight at 40 weeks; 0.06 ± 0.00, -0.11 ± 0.04 and -0.00 ± 0.02 for age at first egg and 0.28 ± 0.01, 0.95 ± 0.04 and 0.61 ± 0.02 for egg weight respectively.

The genetic correlations between body weights at 20 weeks and 40 weeks and between body weights and egg weight were positive, between body weights and age at first egg negative and between age at first egg and egg weight positive. Environmental and phenotypic correlations between the traits were generally of low magnitude.
